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# ROLE OF "STEM CELL" IN DIFFERENT DISEASES & THERAPY

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## ABSTRACT

Stem cells are defined as cells that have clonogenic and self-renewing capabilities and differentiate into multiple cell lineages. Stem cells are found in all of us, from the early stages of human development to the end of life. Stem cell Therapy is emerging as a potentially revolutionary new way to treat disease and injury, with wide-ranging medical benefits. Stem Cell research presents many ethical and scientific questions as well as future challenges. Stem cells are basic cells of all multicellular organisms having the potency to differentiate into wide range of adult cells. In recent years, stem cell therapy has become a very Promising and advanced scientific research topic. Stem cells are unspecialized cells that develop into the specialized cells that make up the Different types of tissue in the human body. In particular, mesenchymal stem cells (MSCs) have been successfully tested in some clinical trials in patients with COVID-19. The encouraging results positioned MSCs as a possible cell therapy for COVID-19. In this paper the goal is Evaluation of cell therapy in treatment of Parkinson's disease, Amyotrophic lateral sclerosis, Alzheimer, Stroke, Spinal Cord Injury, Multiple Sclerosis, Radiation Induced Intestinal Injury, Inflammatory Bowel Disease, Liver Disease, Duchenne Muscular Dystrophy, Diabetes, Heart Disease, Bone Disease, Renal Disease, Chronic Wounds, Graft-Versus-Host Disease, Sepsis and Respiratory diseases. It should be Mentioned that some disease that are the target of cell therapy are discussed in this article.

**KEYWORDS:** Stem cells, embryonic stem cells, adult stem cells, umbilical cord blood, spinal cord stroke, transplants, pluripotency, Alzheimer's disease, injury, regerative medicine.

## I. INTRODUCTION

Stem cells are found in all of us, from the early stages of human development to the end of life. Stem cells are unspecialized cells that develop into the specialized cells that make up the different types of Tissue in the human body. They are characterized by the Ability to renew themselves through mitotic cell division and Differentiating into a diverse range of specialized cell types. Stem cell transplants are used to restore the stem cells when the bone marrow has been destroyed by disease, chemotherapy, or radiation. Depending on the source of the stem cells, this procedure may be called a bone marrow transplant, a Peripheral blood stem cell transplant, or a Cord blood transplant. The review is summarized by challenges that stem cell therapy must overcome to be accepted worldwide. Stem cells have great potential in tissue regeneration and repair but much still needs to be learned about their biology, manipulation and safety before their full therapeutic potential can be achieved.[1] They can all be called hematopoietic stem cell transplants. Stem-cell therapy is the use of stem cells to treat or prevent a disease or condition. As of 2016, the only established therapy using stem cells is hematopoietic stem cell transplantation. Stem cell- based treatments have been established as a clinical standard of care for some Conditions, such as hematopoietic stem cell transplants for Leukemia and epithelial stem cell-based treatments for burns and corneal disorders, the scope of potential stem cell-based therapies has expanded in recent years due to advances in Stem cell research. Stem cells are unspecialized cells that develop into the specialized cells that make up the Different types of tissue in the human body. Stem cells have been suggested as a therapy for lung-related diseases. Stem cells are undifferentiated cells that have the capacity to proliferate in undifferentiated cells both in vitro and in vivo (self-renewal) and to differentiate into mature specialized cells. The distinctive feature of Different stem cell types is based on the capability of the Cells to differentiate along multiple lineages and produce Derivatives of cell types of the three germ layers or to produce multiple cell types. Below different stem cell Types are briefly described. Stem cells can now be grown and transformed into specialized cells with characteristics consistent with cells of various tissues such as muscles or nerves through cell culture. Highly plastic adult Stem cells from a variety of sources, including umbilical cord blood and bone Marrow, are routinely used in medical Therapies. This review focuses on types of Stem cells, their sources, stem cell research and future aspects.[2]

**Stem Cell**

A cell that has the ability to continuously divide and differentiate (develop) into various other kinds of cells or tissues. Stem cell therapy is certainly a promising area for research. These have the ability to give rise to many specialize cells in on organisms. Stem cells could be used to repair or replace damaged organs. Stem cells therapy can cure many diseases. Stem cells are unspecialized or undifferentiated cells that have the unique ability to give rise to many different cell types such as skin, liver, kidney, heart, neuron or other organ cells.[3]

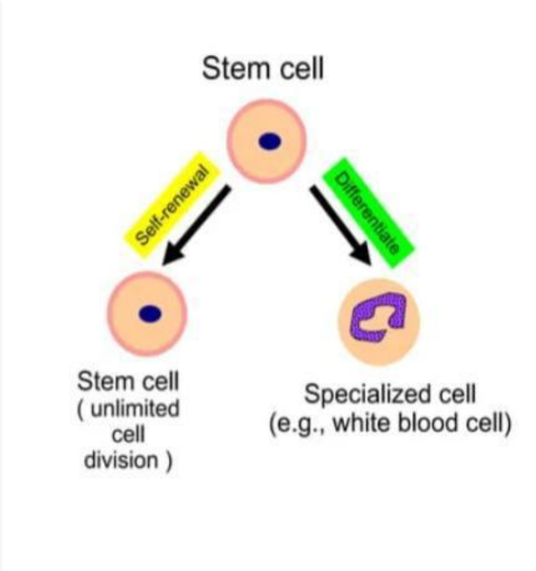


**Fig. 1: Stem Cell.**

**Advantages of Stem Cell Therapy**

1 No risk of rejection
2 No communicable disease transmission
3 General anesthesia is not necessary
4 Fast recovery
5 Powerful results
6 Minimally invasive

The unique properties of all stem cells:

a. Undifferentiated or unspecialized cells undifferentiated cells can differentiate to yield major specialized cell types or organs.
b. Self-renewal property is to maintain and repair the tissue. Thus they have potential to replace cell tissue damaged by severe illnesses.
c. All stem cells-regardless of their source have three general properties.
d. They are capable of dividing and renewing themselves for long periods.
e. They are unspecialized they can give rise to specialized cell types.

**Potential Uses of Stem Cells[4]**

Basic research clarification of complex events that occur during human development & understanding molecular basis of cancer. Molecular mechanisms for gene control. Role of signals in gene expression & differentiation of the stem cell Stem cell theory of cancer.

**Stem cell therapy procedure**

Stem cell transplantation (SCT), sometimes referred to as bone marrow transplant, is a procedure in which a patient receives healthy stem cells to replace damaged stem cells. Before SCT, the patient receives high doses of chemotherapy, and sometimes radiation therapy, to prepare the body for transplantation.

**How stem cell therapy works**

Stem cells that give rise to the lymphocytes and other cells of the immune system, also make blood cells, are called hematopoietic stem cells. HSC's are characterized by the presence of CD 34 antigen. The process of taking stem cells from one person and putting them into another is therefore called "HCST".

**USES**

- To treat cancer patients with conditions such as leukemia and lymphoma, sickle cell anemia.
- Used in providing a functional immune system in a person with SCID. In Restoring the hematopoietic system

## II. STEM CELL CULTURE[5,6]

Growing cells in the laboratory is known as cell culture. Human embryonic stem cells (hESCs) are generated by transferring cells from a preimplantation- stage embryo into a plastic laboratory culture dish that contains a nutrient broth known as culture medium. The cells divide and spread over the surface of the dish. The process of re- plating or sub culturing the cells is repeated many times and for many months. Each cycle of sub culturing the cells is referred to as a passage. Once the cell line is established, the original cells yield millions of embryonic stem cells. Embryonic stem cells that have proliferated in cell culture for six or more months without differentiating, are pluripotent, and appear genetically normal are referred to as an embryonic stem cell line. At any stage in the process, batches of cells can be frozen and shipped to other laboratories for further culture and experimentation.

**Stem Cell Lines**

A stem cell line is a family of constantly dividing cells, the product of a single parent group of stem cells. They are obtained from human or animal tissues and can replicate for long periods of time in vitro ("within glass"; or, commonly "in the lab", in an artificial environment). They are frequently used for research relating to embryonic stem cells or cloning entire organism. Once stem cells have been allowed to divide and propagate in a controlled culture, the collection of healthy, dividing, and undifferentiated cells is called a stem cell line.

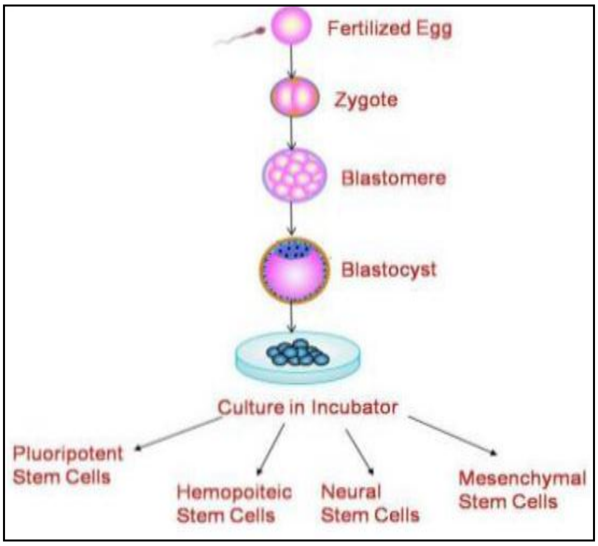


**Fig. 2: Stem cell culture & stem cell lines.**

## III. CLASSIFICATION[7,8]

**Classification of stem cells on the basis of potency**

Stem cells can be classified by the extent to which they can differentiate into different cell types. These four main classifications are totipotent, pluripotent, multipotent, oligopotent unipotent.

### A. Totipotent

Totipotent stem cells are able to divide and differentiate into cells of the whole organism. Totipotency has the highest differentiation potential and allows cells to form both embryo and extra-embryonic structures. One example of a totipotent cell is a zygote, which is formed after a sperm fertilizes an egg. These cells can later develop either into any of the three germ layers or form a placenta. The ability to differentiate into all possible cell types. Examples are the zygote formed at egg fertilization and the first few cells that result from the division of the zygote. Totipotent stem cells can differentiate into embryonic as well as to extraembryonic cell types.

### B. Pluripotent

The ability to differentiate into almost all cell types. Examples include embryonic stem cells and cells that are derived from the mesoderm, endoderm, and ectoderm germ layers that are formed in the beginning stages of embryonic stem cell differentiation.

### Multipotent

The ability to differentiate into a closely related family of cells. Examples include hematopoietic (adult) stem cells that ann. become red and white blood cells or platelets. Multipotent stem cells have a narrower spectrum of differentiation than PSCs, but they can specialize in discrete cells of specific cell lineages.

### C. Oligopotent

Oligopotent stem cells can differentiate into several cell types. A myeloid stem cell is an example that can divide into white blood cells but not red blood cell.

### D. Unipotent

The ability to only produce cells of their own type, but have the property of self- renewal required to be labeled a stem cell. Examples include (adult) muscle stem cells.

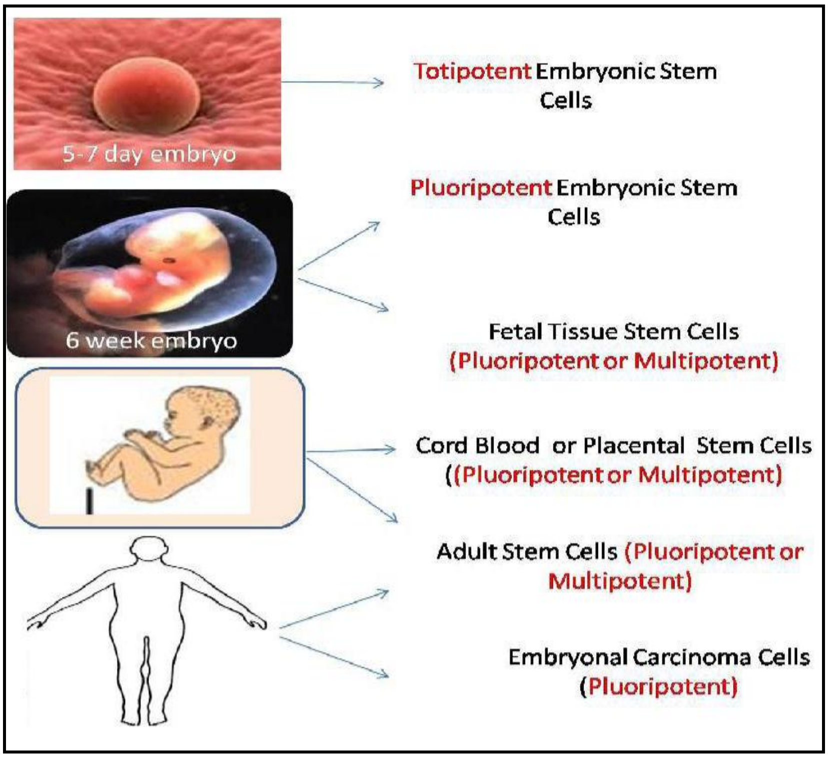


**Fig. 3: Classification of stem cell on the basis of potency.**

**Classification of stem cells on the basis of their sources[9]**

**A. Embryonic stem cells**

Embryonic stem cells are self-Replicating pluripotent cells that are potentially immortal. They are derived from embryos at a developmental stage before the time of implantation would normally occur in the uterus. The embryos from which human embryonic stem cells are derived are typically four or five days old and are a hollow microscopic ball of cells called the blastocyst. Embryonic stem cells (ESCs) are pluripotent stem cells derived from the inner cell mass of a blastocyst, an early-stage pre-implantation embryo. Human embryos reach the blastocyst stage 4–5 days post fertilization, at which time they consist of 50–150 cells. Researchers are currently focusing heavily on the therapeutic potential of ESCs. Although embryonal stem cells (ESC) are pluripotent cells that have the ability to differentiate into derivatives of all three germ layers (endoderm, mesoderm, and ectoderm). The most common assay for demonstrating pluripotency is teratoma formation. However, pluripotent stem cell lines must be able to fulfill several other specific features. Stem cell lines have the ability to grow indefinitely and express ESC markers and show ESC-like morphology. In addition, the cell line forms embryonic bodies (in vitro) and or teratomas (in vivo) containing all 3 germ layers. In mice pluripotent stem cells have the ability to form chimeras upon injection into early blastocysts. ESC is derived from totipotent cells of the inner cell mass of the blastocyst, an early stage mammalian embryo.

**Advantages of ES cells**

I general, the cultures from embryonic tissues survive, and proliferate better than those from the adult. This is due to the fact that ES cells are less specialized with higher proliferative potential. Limitations of ES cells in some cases, the ES cells will be different from the adult cells, and thus there is no guarantee that they will mature to adult-type cells. Therefore, it is necessary to characterize the cells by appropriate.

**B. Adult stem cells**

Adult stem cells are undifferentiated totipotent or multipotent cells, found throughout the body after embryonic development, that multiply by cell division to replenish dying cells and regenerate demaged tissues. The primary roles of adult stem cells in a living organism are to maintain and repair the tissue in which they are found. Unlike embryonic stem cells, which are defined by their origin (the inner cell mass of the blastocyst), the origin of adult stem cells in some mature tissues is still under investigation.

**Types of Adult Stem Cells[10]**

a. Hematopoietic Stem Cells (Blood Stem Cells)
b. Mesenchymal Stem Cells.
c. Neural Stem Cells.
d. Epithelial Stem Cells.
e. Skin Stem Cells

**IV. DISEASE CURED BY STEM CELL THERAPY[11,12,13]**

**Possible Treatments by Stem Cells**

A number of stem cell therapeutics exist, but most are at experimental stages and costly, with the notable Exception of bone marrow transplantation. Medical researchers anticipate that adult and embryonic stem cells will soon be able to treat cancer, Type 1 diabetes mellitus, Parkinson’s disease, Huntington’s disease, Celiac Disease, cardiac failure, muscle damage and neurological disorders, and many others.

**Umbilical cord Stem Cells**

At the time of delivery, cord blood is collected, stored, and frozen. UCB contains two Umbilical cord blood is often stored after birth.

Classes of stem cells.

- Haematopoietic stem cells (HSC).
- Mesenchymal stem cells (MSC).

Can be used to cure chronic blood-related disorders such as sickle cell disease, Thalasemia, and leukaemia. A large number of stem cells are found in blood of newborn babies. After birth, the blood that is left behind in the placenta and umbilical cord (cord blood) can be taken and stored for later use in a stem cell transplant. The cord blood is frozen until needed. A cord blood transplant uses blood that normally is thrown out after a baby is born.

**How Umbilical Cord Blood Is Collected**

After the umbilical cord is clamped and Cut, the placenta and umbilical cord are cleaned. The cord blood is put into a sterile container, mixed with a preservative, and frozen until needed.

- **Bone marrow**

Bone Marrow transplants (BMT) are a well known clinical application of stem cell transplantation. BMT can repopulate the marrow and restore all the different cell types of the Blood after high doses of chemotherapy and/or radiotherapy, our main defense used to eliminate endogenous cancer cells. The isolation of additional stem and progenitors cells is now being developed for many other clinical applications.

- **How Bone Marrow Stem Cells Are Collected**

This process is often called bone marrow Harvest, and it’s done in an operating Room. The donor is put under general anesthesia while bone marrow is taken. The marrow cells are taken from the back of the pelvic (hip) bone. A large needle is put through the skin and into the back of the hip bone. It’s pushed through the bone to the center and the thick, liquid marrow is pulled out through the needle. This is repeated several times until enough marrow has been taken out. The amount taken depends on the donor’s weight. Of about 10% of the donor’s marrow, or about 2 pints, are collected. This takes about 1 to 2 hours. The body will replace these cells within 4 to

6 weeks. If blood was taken from the donor before the marrow donation, it's often given back to the donor at this time.

- **Skin replacement**

The knowledge of stem cells has made it possible for scientists to grow skin from a patient‘s plucked hair. Skin (keratinocyte) stem cells reside in the hair follicle and can be removed when a hair is plucked16. These cells can be cultured to form an epidermal equivalent of the patients own Skin and provides tissue for an autologous graft, bypassing the problem of rejection.

- **Brain cell transplantation**

Stem cells can provide dopamine a chemical lacking in victims of Parkinson‘s disease. It involves the loss of cells which produce the neurotransmitter dopamine. The first double-blind study of fetal cell transplants for Parkinson‘s disease reported survival and release of dopamine from the transplanted cells and a functional improvement of clinical symptoms. However, some patients developed side effects, which suggested that there was an over sensitization to or too much dopamine. Although the unwanted side effects were not anticipated, the success of the experiment at the cellular level is significant.

- **Baldness**

Hair follicles also contain stem cells, and some researchers predict research on these follicle. Stem cell may lead to successes in treating baldness through "hair multi-placation" and known as "hair cloning" as early 2011. This treatment is expected to work through taking stem cells from existing follicles, multiplying them in cultures, and implanting the new follicle cells which have shrunk during the ageing process, which in turn respond to these signals by regenerating and once again making healthy air.

**Treatment for diabetes[14]**

Diabetes affects millions of people in the world and is caused by the abnormal metabolism of insulin. Normally, insulin is produced and secreted by the cellular structures called the islets of langerhans in the pancreas. Recently, Insulin expressing cells from mouse stem cells have been generated. In addition, the cells self assemble to form structures, which closely resemble normal pancreatic islets and produce insulin. Future research will need to investigate how to optimize conditions for insulin production with the aim of providing a stem cell-based therapy to treat diabetes to replace the constant need for insulin injections.

**1. Stem Cell Therapy for HIV**

The hematopoietic stem cell has long been hypothesized to be a target of human immunodeficiency virus type-1 (HIV) infection that limits the potential for compensatory immune cell production. Data have recently emerged documenting stem cell dysfunction in HIV disease and indicating that immune recovery from potent antiretroviral therapy is partly driven by new T-cell generation. Effects of HIV on stem cell physiology, however, appear to be indirect, as stem cells are highly resistant to HIV infection. Despite the presence of surface receptors for HIV, the hematopoietic stem cell is not infectible with HIV and can serve as a resource for cellular therapies for AIDS.

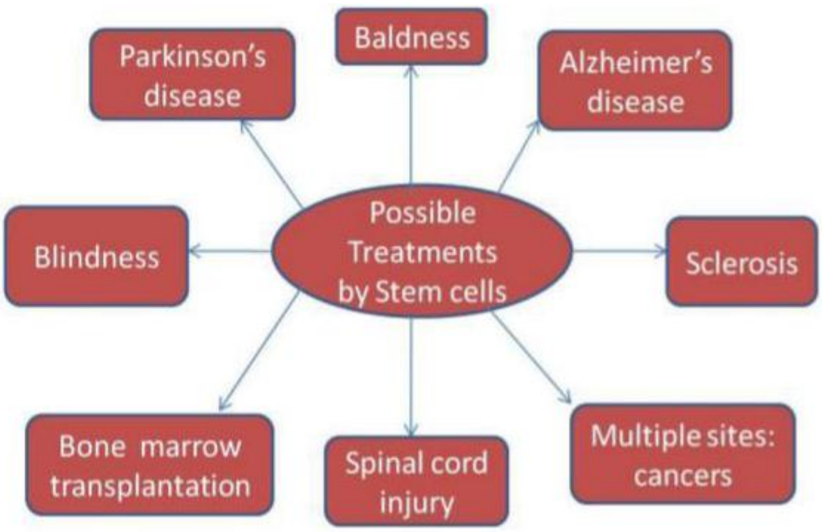


**Fig. 4: Possible treatment of Stem cells.**

**2. Stem Cell Therapy in Parkinson's disease**

Dopamine (DA), a key neurotransmitter that transmits signals between neurons, plays an essential role in motor control. PD is the second-most-common age-related progressive neurodegenerative disorder caused by DA deficits in the striatum due to the destruction of DA-producing neurons located in the substantia nigra. The initial symptoms are sometimes barely noticeable, such as tremors affecting one hand or the slowing of movement. As the disease progresses, controls over movement are entirely compromised, and patients may present symptoms such as muscle tremors, muscle rigidity, slowing of voluntary movement, postural instability, bradykinesia, and other motor dysfunctions, usually in the fifth to seventh decade of life. To date, approximately 60,000 Americans are diagnosed with PD yearly, and more than ten million people worldwide are suffering from PD.

### 3. Stem cell therapies for COVID-19

Stem cell contribution to current medicine is central, both for their use in basic research, and for the opportunities to develop innovative therapies in clinical practice. The urgency of finding new and effective treatments against COVID-19 has positioned stem cells at a strategic place in the scene. Since COVID-19 emerged, several groups have dedicated their efforts to this topic. In this way, Han et al. have derived lun organoids from human-induced pluripotent stem cells in order to analyze COVID-19 consequences and possible drug treatments. The alveolar type II cells from the organoids expressed ACE2 and were susceptible to virus infection. They also tested the potential of virus infection in mouse xenografts models. In both cases, the Presence of SARS-CoV-2 virus was detected after 24 h of infection. This group identified some drug candidates—approved by the Food and Drug Administration (FDA)—that were able to block the RNA virus replication: imatinib, mycophenolic acid, quinacrine dihydrochloride, chloroquine, and prochlorperazine. They provided evidence that support the use of these drugs in clinical trials.

### 4. Stem cell Therapy for Multiple Sclerosis

Multiple sclerosis (MS) is an autoimmune disease. Your immune system attacks your central nervous system and damages your nerve fibers. That makes it hard for your brain to “talk” with the rest of your body and causes symptoms like weakness, tingling or numbness in your limbs, trouble speaking, chronic pain, depression, and vision loss. Several medications are used to treat MS. They can cause serious side effects, and over time, they can stop working for some people. But a new treatment involving stem cells may work for people who have relapsing-remitting MS (RRMS) and haven’t been helped by other medicines.

### 5. Treatment for diabetes

Diabetes affects millions of people in the world and is caused by the abnormal metabolism of insulin. Normally, insulin is produced and secreted by the cellular structures called the islets of langerhans in the pancreas. Recently, insulin expressing cells from mouse stem cells have been generated. In addition, the cells self assemble to form structures, which closely resemble normal pancreatic islets and produce insulin. Future research will need to investigate how to optimize conditions for insulin production with the aim of providing a stem cell-based therapy to treat diabetes to replace the constant need for insulin injections.

## V. STEM CELL TRANSPLANT SIDE EFFECTS[15,16]

- **Mouth and throat pain**

Mucositis (inflammation or sores in the mouth) is a short term side effect that can happen with chemo and radiation. It usually gets better within a few weeks after treatment, but it can make it very painful to eat and drink.

- **Nausea and vomiting**

Because chemotherapy drugs can cause severe nausea and vomiting, doctors often give anti-nausea medicines at the same time as chemo to try and prevent it.

- **Infection**

During about the first 6 weeks after transplant, until the new stem cells start making white blood cells (engraftment), you can easily get serious infections. Bacterial infections are most common during this time, but viral infections that were controlled by your immune system can become active again. Fungal infections can also be an issue.

- **Bleeding and transfusions[17]**

After transplant, you‘re at risk for bleeding because the conditioning treatment destroys your body‘s ability to make platelets. Transplant problems that may show up later:

Possible long-term risks of transplant include

- Organ damage
- Relapse (the cancer comes back)
- Secondary (new) cancers
- Abnormal growth of lymph tissues
- Infertility (the inability to produce children)
- Hormone changes, such as changes in the thyroid or
- Pituitary gland
- Cataracts (clouding of the lens of the eye, which causes Vision loss).

## VI. CONCLUSION[18-19]

In conclusion, stem cell therapy is the future of regenerative medicine and more research is needed to understand the exact biology and the therapeutic potential of stem cells. Stem cell-based treatment is exciting, that most likely benefit the human health. In this rapidly growing field, the potential to develop innovative stem cell-based therapies is indeed very attractive. Although such therapies evolve in a Scientific and ethical manner, unregulated stem cell treatments are already being offered by many hospitals around the world. Therapeutics in the form of Bone Marrow transplant (BMT), Skin replacement, and Organ development, replacement of lost tissues such as hair, tooth, retina & cochlear cells much more needed. Tissue banks are becoming increasingly popular, as they gather cells that are the source of regenerative medicine in a struggle against present and future diseases. After several decades of experiments, stem cell therapy is becoming a magnificent game changer for medicine. We conclude that ongoing research on stem cell therapies gives hope to patients who would normally not receive treatment to cure their disease. Stem cells have a bright future for the therapeutic world by promising stem cell therapy. There is enormous potential in human stem cell research both adult and embryonic stem cells should be studied much research needed before therapies are realized.

## VII. REFERENCES


1 Avasthi S, Srivastava RN, Singh A, Srivastava M. Stem Cell: Past, Present and Future- A Review Article. Internet Journal of Medical Update, Jan-Jun, 2008; 3(1): 22-30.

2 Trounson A, McDonald C. Stem Cell Therapies in Clinical Trials: Progress andChallenges. Cell Stem Cell, 2015; 17: 11-22. 10.1016/j.stem.2015.06.007.

3 Pérez López S, Otero Hernández J. Advances in stem cell therapy. Adv Exp Med Biol., 2012; 741: 290-313. 10.1007/978-1-4614-2098-9_19

4 Zakrzewski et al. Stem cell reasearch and tharpy stem cells: past present and future (2019).

5 Riedel et al. Stem cell research and therapy (2021) stem cells and COVID – 19 are the human amniotic cells a new hope for therapies against the SARs-COV- 2 virus.

6 Herberts et al. Journal of translational medicine (2011) risk factors in the development of stem cell therapy.

7 Farzane sivanzade and Luca cucullo regenerative stem cell therapy (2021).

8 Bagher Larijani, mohabbad ali sahraiav Yahya dowlati, ardesgir ghavamzadesh, kamran alimoghaddam, stem cell therapy in treatment of different diseases (2012) acta madica Iranica.

9 Tateishi K, Takehara N, Matsubara H, Oh H. Stemming heart failure with cardiac- or reprogrammed-stem cells: Stem cells review series. J Cell Mole Med., 2008; 12: 2217–32.

10 Fortier LA. Stem cells, classification, controversies and clinical applications. Vet Surg, 2005; 34: 415–23.

11 Wang X, Yang YJ, Jia YJ, et al. The best site of transplantation of neural stem cells into brain in treatment of hypoxic-ishemic damage: experiment with newborn rats. Zhonghua Yi Xue Za Zhi, Mar 27, 2007; 87(12): 847-50.

12 Jesse K. Biehl, BS, Brenda Russell Introduction to Stem Cell Therapy, J Cardiovasc Nurs., 2009; 24(2): 98–105.

13 Kalra K and Tomar PC, Stem Cell: Basics, Classification and applications. American Journal of Phytomedicine and Clinical therapeutics, AJPC., 2014; 2(7): 919-930.

14 Sonntag, K.-C.; Song, B.; Lee, N.; Jung, J.H.; Cha, Y.; Leblanc, P.; Neff, C.; Kong, S.W.; Carter, B.S.; Schweitzer, J. Pluripotent stem cell-based therapy for Parkinson's disease: Current status and future prospects. Prog. Neurobiol, 2018, 168: 1–20. Zhang, B.; Yan, W.; Zhu, Y.; Yang, W.; Le, W.; Chen, B.; Zhu, R.; Cheng, L. Nanomaterials in neural-stem-cell-mediated regenerative medicine: Imaging and treatment of neurological diseases. Adv. Mater., 2018; 30: 1705694.

15 Wang, Y.; Ji, X.; Leak, R.K.; Chen, F.; Cao, G. Stem cell therapies in age-related neurodegenerative diseases and stroke. Ageing Res. Rev., 2017; 34: 39–50.

16 Wen, M.M.; El-Salamouni, N.S.; El-Refaie, W.M.; Hazzah, H.A.; Ali, M.M.; Tosi, G.; Farid, R.M.; Blanco-Prieto, M.J.; Billa, N.; Hanafy, A.S. Nanotechnology-based drug delivery systems for Alzheimer's disease management: Technical, industrial, and clinical challenges. J. Control. Release, 2017; 245: 95–107.

17 De Gioia, R.; Biella, F.; Citterio, G.; Rizzo, F.; Abati, E.; Nizzardo, M.; Bresolin, N.; Comi, G.P.; Corti, S. Neural Stem Cell Transplantation for Neurodegenerative Diseases. Int. J. Mol. Sci., 2020; 21: 3103.

18 Review of 4 cell therapy types under study for COVID-19 By Mina Kim August 3, 2020 / Capricor COVID-19, cardiac regeneration, Cell therapy COVID-19, Mina Kim, Paul Knoepfler, Stem cells COVID-19, Stem cells for COVID-19 / Blog, COVID-19